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JUNE 1, 1919

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# AVIATION AND AERONAUTICAL ENGINEERING



The New Army Airship A-4 at its Trials

VOLUME VI  
Number 1

## SPECIAL FEATURES

DEVELOPMENT OF THE NC SEAPLANES  
NAVAL AIRSHIP C-5 MAKES 1100-MILE FLIGHT  
COURSE IN AERODYNAMICS AND AIRPLANE DESIGN  
VENEER BODY CONSTRUCTION  
CHART FOR PERFORMANCE COMPUTATIONS

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March 24, 1939



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American Bronze Corporation  
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HIGH SPEED  
**NON-GRAN**  
BEARING BRONZE

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The C. M. O. Physical Laboratory, Inc., Buffalo, N. Y. inserts the following advertisement concerning the unique propellers, which because of high efficiency were selected by the Navy for the trans-Atlantic NC boats.

**DESIGNER:** Charles M. Olmsted, A.B., A.M., Harvard, Ph.D. Univ. of Bonn; formerly a physicist of the Carnegie Institution of Washington, now president of the C. M. O. Physical Laboratory, Inc.

**DIFFERENCE:** The basic underlying theory, according to which the radial distribution of blade surface and angle is determined, is original with Dr. Olmsted, and the resulting blade is much wider at the base and narrower at the tip than standard practice.

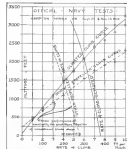
This is clearly seen in the above photograph of the Navy trans-Atlantic hydro-aeroplane equipped with Olmsted propellers.

**ADVANTAGE:** Olmsted propellers invariably hold the motor to within a few per cent of the predetermined revolutions and deliver at these revolutions a greater flying thrust than is attainable with any other blade.

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**PATENTS:** The Olmsted type of blade is fully covered by U. S. and foreign basic form patents which are owned by

THE C. M. O. PHYSICAL LABORATORY, INC., BUFFALO, N. Y.





**UNION GAS ENGINE CO. OAKLAND CALIFORNIA**

JUNE 1, 1919

# AVIATION AND AERONAUTICAL ENGINEERING

VOL. VI. NO. 9

*Member of the Audit Bureau of Circulations*

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We are justly proud of our contribution to the General Aeronautical Program.

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BUSINESS MANAGER

Vol. VI

June 1, 1935

No. 9

THE brilliant success which attended the progress of the NC Seaplane Division 1 in its flight to the Azores, and which was earned only in part by the fog, is a lasting testament to the professional skill of our naval aviators as well as to the worth of American airplane construction.

While Commander Read carried off the honors for sheer flying performance by making a 1,500-mile non-stop flight from Trepassey to Horta, Commander Townes' successful sailing of his disabled seaplane for two days in heavy seas and storms is an achievement that deserves a place of its own in the annals of aviation. The surface course of 500 miles brilliantly shows up the seaworthiness of the large boat-type seaplane, originated and developed by Glenn H. Curtiss, and its great possibilities for ocean travel, while it sheds a new light on the art and maintenance of the United States Navy.

While Commander Hollister has been successful in his attempt to reach the Azores with the NC-1, his flight, which ended last 100 miles off the goal, is evidence of the confidence of the Liberty engine, which worked faithfully on all the three seaplanes.

### Harker and Griever

The unsuccessful attempt of Harry G. Harker and Commander Blackhawk Griever, R. N., to win for Great Britain the blue ribbon of the transatlantic flight is a tale of heroism which will be readily accepted upon the rules of honor of the British race and of mankind.

To attempt to cross 3000 miles of ocean without alighting on a land machine demands more than ordinary determination and endurance; therefore the news that the two gallant Britons have been rescued after hope had almost dwindled as to their chance of survival will create universal sympathy.

### The Flight of the C-5

The intricate character of the United States naval airship C-5 affords a highly instructive object lesson to all those concerned with the development of lighter-than-air craft.

On the one hand, we have the outstanding fact of an American-built and American-manned airship of comparatively small size—160,000 cu. ft.—making under most adverse weather conditions a non-stop cruise of 1,100 miles and reaching its destination according to plan, which demonstrates that the airships of the United States Navy are, within their class, second to none.

On the other hand, the unfortunate loss of the C-5 serves to indicate that the problem of mooring an airship in a wind swept area has not been fully solved as yet.

The three-point ground anchorage for airships, which failed at Newfoundland, answers the purpose under average weather conditions, and has the merit of low cost and ease of assembly. But in a gale this mooring puts the airship and rigging of a mooring to an unduly high strain because the wind swings upon the airship tangentially instead of normally, thus gives, furthermore, rise to a lifting component which varies with the strength of the wind and therefore causes longitudinal oscillations. In other words, the airship judders on its moorings, with the ensuing risk of having the airship damaged if the wind be strong enough.

Experiments carried out abroad lead to the conclusion that stability on the moorings can best be overcome by the use of mooring masts provided with a canvas cap, to which the airship fastens her nose and then swings freely with the wind. Of course, moorings require special reinforcement on the nose, but otherwise the solution appears extremely simple and workable; it has in fact given remarkable results abroad, even ships thus moored having withstood winds of 50 m. p. h. The development of a mooring mast, built in sections so it could be easily transported, assembled and taken down again, therefore seems to demand the immediate attention of airship constructors.

### The Air Mail Service

The first annual report on the operation of the air mail service between Washington and New York, which has just been made public by the Post Office Department, is a document of more than passing interest and its perusal is well worth the time of all those interested in the development of commercial aeronautics.

The outstanding features of this report are: that out of a possible 138,310 miles there were flown 128,255 miles, that is, a performance of 92.3 per cent; that out of 1,200 trips only 55 were not undertaken or failed for various reasons—a default of only 4.6 per cent; that during these twelve months there have been only thirty-seven forced landings, that the six airships which entered upon this service a year ago are, with the same engines, still in commission, rendering continuous service; that there has occurred no single fatal accident and only two serious and six light injuries in flying operations; and finally, that the balance sheet of the service shows a net surplus of over \$19,000.

The record of the air mail set only barely testimony to the careful and efficient manner in which the service has been operated by Rosa Otto Prager and his associates; it also proves beyond dispute that the era of aerial transport has truly arrived.

ac

## Development of the NC Seaplanes

The history of the inception and development of the NC seaplanes, with additional information on some of their authentic unknown constructional features and equipment, has been made public by the Navy Department and is printed herewith in part.

The inception of the NC type of seaplane dates from Aug. 27, 1914, when Rear Admiral David W. Taylor, Chief Constructor of the Navy, suggested as a recommendation to Naval Constructor J. C. Henshaw, U. S. N., his assistant for aeronautics, the desirability of developing "a big flying boat, of the suspended type, that would be able to keep the sea (and the air) in any weather and also be able to fly across the

ocean, without landing on the water and without the necessity of the wings being folded in any way on the water." This plan was adopted, on view of the greater seaworthiness, weight-saving, and ease of the wing, which a construction appeared to present.

Plans were then prepared in the Bureau for a boat of the character to be fitted with three engines, and for one to be

June 1, 1915

project back over months besides ruling the issue of no to eight sets of the crew.

The design being worked upon was of dimensions to far beyond any previous experience in the country or any of the designs in the United States that such a standard form would have to be secured. In order that the design might be successful, new methods of construction would be required, as otherwise the weight of the design would increase with such equality as to make a mere experiment. In the work of design information and knowledge as it existed in the United States on that date, the necessity was one of the greatest emergencies, and one which required upon the personnel associated with the design a great amount of investigation and experimenting in the working out of the details referred to.

work coming under that term, and for the purpose placed in charge, as its field representative, Naval Constructor U. L. Westerville, U. S. N., whose headquarters were at the plant of the Curtiss Aeroplane and Motor Corp. in Buffalo. Actual work on the vital design was begun in Buffalo early in October. Shortly after the commencement, Naval Constructor H. C. Richardson, U. S. N., was ordered for temporary duty in connection with the design of the hulls for the boats, and temporarily left his station at the Naval Air Station, Pensacola, Fla., to go to Buffalo.

### Hull Design

The hull designed by the chief was of novel form and construction, and embodied directly information obtained



FORWARD AND MIDDLE PORTIONS OF THE NC-1. WHEN PAINTED IN WHITE, IT WAS CALLED "WHITE ENEMY" BY THE ENEMY.

Admiral to avoid collection of debris, and whenever the emergency means could be shown, not only destroyed, from the air. Attention was called to this construction in the fact that the Liberty engine gave a good record of being in service and would therefore furnish a satisfactory power plant for these seaplanes.

Studies were immediately undertaken by the Admiral's Bureau, Bureau of Construction and Repair, to apply the Liberty engine to a large seaplane.

Admiral Taylor, after discussion of the problem, directed the preparation of tentative plans to show in a preliminary way the size and nature of a design of large flying boat to combine the maximum of seaworthiness consistent with sufficient endurance to fly across the Atlantic to the mid-oceanic operating bases in France and England and to be capable of carrying heavy depth charges and a large battery of machine guns covering every angle of fire. It was anticipated that the boat would be attacked in the air by enemy aircraft.

### Preparation of Plans

On Sept. 5, 1915, Glenn H. Curtiss was requested by a note to come to Washington to discuss the proposed design, agreed the following day, with Joseph W. L. Ottens and Henry Kiehl. Mr. Curtiss and his engineers went over the

drawings with the engines. The projected performance was compared for each boat, from which it appeared that the three-engine boat would be made to satisfy the general requirements of the problem and could be made more quickly built and with smaller risk of failure. Admiral Taylor accordingly directed that the design staff of the Bureau be put on the plan of the three-engine type. Investigations were at once undertaken to determine in a preliminary way the construction of hull, boom, struts, and the principal structural members, the portions of wing area, fin, and control surface areas, etc., and the materials to be employed for reported parts. The general appearance of the design was worked out, and the procedure established to be followed in making the final drawings.

### Wind Tunnel Tests

A three-foot model of the design was then made, built in scale and tested by Dr. A. P. Zahm in the wind tunnel at the Washington Navy Yard. From his investigations of the forces on this model, when held in a steady wind as high as 100 miles an hour, and arrangement of tail surfaces to maintain stability and control balance in flight were suggested. With a machine of the sophisticated type employed it was actually necessary that there should be no doubt in the case, as an accident in the final flight would be



MIDDLE PORTION OF THE NC-3—NOTE THE CHANGE IN THE POSITION OF THE WING BRIDGE.

It was become apparent that the carrying on of the completion of design work on such dimensions at the Bureau of Construction and Repair in Washington would be impracticable unless the entire facilities of that Bureau were devoted to this work. Under the auspices of the Navy Department, in connection with the other Bureau of the Navy Department, the work was carried out, and it was decided to arrange with the Curtiss Aeroplane and Motor Corp. of Buffalo, N. Y., to complete the drawings with their own design facilities, and with the construction by themselves of such scale as that might develop under the control and supervision of the Bureau.

### Control for Seaplanes

A control was therefore made with the Curtiss Co. for the performance of the drawing and design work. Under the terms of the contract it was to carry out all the work directed by the Navy Department, furnishing no resources, financial or in other manner. The Bureau of Construction and Repair reserved to itself the direction and oversight of all

from his successful seaplane projects. The first test showed that the form adopted represented a very expensive improvement over the conventional three boat hulls. The tests were based on model experiments. A series of models of hulls were made up and tested by Naval Constructors McEldine and Richardson in the towing tanks of the Washington Navy Yard, and the physical properties of each investigated. The best of the series was adopted for the form of the three boat, with modifications that there would be no disappointment in the breaking away from the water. To the working out of the structural details of the hull's hull W. L. Skinner of the Curtiss Co. contributed much valuable assistance.

This large flying boat was very shortly designated as the NC-1. In this designation the "N" is for the Navy, the "C" for Curtiss, and the "1" is intended to indicate the first of a series of combined Navy Curtiss designs. As the main work indicated, the design itself is a composite of ideas, those ideas being contributed by many persons, and being tested and incorporated into the design on the basis of stability and work and without any reference to name.



(for maintenance of equipment) weighs only 2,000 lb., yet the displacement is 26,000 lb., or one-tenth of a pound of load per pound of displacement. This lightweight, non-corrosive material is a critical selection and distribution of materials. The tool is of 5086 alloy, as is the plugging. Longitudinal strength is given by two gardens of alloy bonded with steel wire. To guarantee uniformity and to keep the plugging thin, there is a layer of resin set in epoxy glue between the two plates of 5086 alloy.

### Ring Construction

The weight of H. A. F. 6 curve and cast is light a maximum load of 117 lb./sq. in. The structural weight of the engine is 120 lb. per ft. The total engine weight is 1,400 lb. (1).

Wings of this size could not be manipulated by the usual method and animals without naturally exceeding this figure.

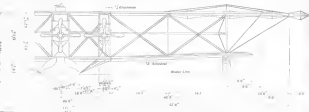


Figure 1 illustrates that the NP 1 is dominated by the following

and a great amount of research and experiment has been necessary to determine the best disposition of material to adopt.

The main wing (spine) are brown spruce beetle. The hole is a trace designed like a bridge, consisting of continuous narrow strips of spruce, corresponding to the upper and lower chords of a bridge truss, and together by an universal web system of vertical or diagonal pieces of spruce. The ribs are 12 in. long, but each weigh 30 in. each. They and these ribs were captured 30 north a point head of 450 lb. of sand bar 34 in. southeast down.

An interesting detail of the wing construction is the longed leading edge which unites the ventral cables to the struts, or wing ribs. This eliminates the air bracings of these cables, but at the same time they are necessary for supports a by itself, assuming up the leading edge on its hinges.

The wires are arranged as a helix with 11 concentric turns and serve to give girder strength. For highway bridges the strands are made up as a sprue box, but to decrease resistance that sprue portion is tapered to a taper of 100:1. To reduce girder loadings of the wires to low water level, the outside points are connected with a steel cable. The diagonal bracing between the wires is by means of a steel cable in pairs. Three cables are arranged to be one behind the other with a space in between to reduce resistance.

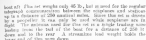
Adrenergic are filled in the upper planes only and project 6 ft. beyond them. Their total area is 285 sq. ft.

The wind possesses such power (80 lb and up to 1,000 lb) that the metal fittings which streets and wires are fastened to the poles presented a serious problem. The danger to be taken care of was as large that it was necessary to eliminate the danger, at least, of the wires hanging down and being in the hands of children. All trees, bushes or poles were cut through a convenient source. In this case, as in a soft bridge, the ropes are all applied to a large hollow ball at the center of the wire basket. In the design of the metal fitting, to reduce the moment

## Tail Streamers

The tail structure is kept up in the form of a bag-like, air-supported structure. These air-filled balloons, by their ability to expand, keep the tail straight and in a single way, so as to remain clear of all breaking waves and to avoid a dangerous position for the bird straight after from the stress compartment without injury to it. This method of supporting the tail structure, beside maintaining several other advantages such as the reduction of frictional resistance of the tail, has resulted in an important saving in weight.

The horizontal stabilizer has a total area of 201.6 sq. ft., and the elevators, 240 sq. ft. The total area of the three surfaces is 692 sq. ft.



With this transmitter it is possible for the command-and-control officer to send messages from time to time regarding the

doi:10.1017/S0007122612000111



By 1998, 70% of the 100,000+ people living in the city of Los Angeles were Hispanic.

It is easy enough for sheet designers to get communication with an ordinary microphone, but the long range of it is impossible without the ultrasonic transmitter.

One of the main advantages of the radio installations on these airplanes is the radio compass. This consists of a set of revolving coils mounted in the tail of the machine, on which are mounted many turns of enameled copper wire. The radio waves are picked up on these coils by revolving the coils until the radio signals obtained on two methods of connection are of the same strength.



$\frac{d}{dt} \left( \frac{1}{r^2} \right) = -\frac{2}{r^3} \frac{dr}{dt}$

The operator then knows the direction of the incoming waves. By then reading the position of a pointer on a scale

on the radio, the breaking of the transmitting radio system is determined. This bearing is then communicated by the radio operator to the navigating officer by means of the intercommunicating triphone, which consists of telephone receivers built into the scheme, and the same type of microphone used in the operation.

Using the same inter-communicating telephone system, the navigator can telephone to the pilots, giving them the proper direction in which to steer the plane. He may inquire of the engine room regarding the condition of the engines, or he may hold radio telephone conversations with the navigating officer on one of the other ships.

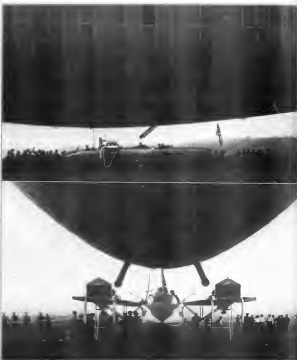
<sup>1</sup> In other words, the intercommunicating telephone makes possible constant communication between all members of the crowd in spite of the terrific noise caused by the engine and the wind rush, and in spite of the fact that they are located in separate parts of the amphitheatre. In addition to this the

The radio compass signals may be received from a shore-station at a distance of 35 miles, or from large land stations at a distance of 500 miles.

The most striking fact regarding this radio equipment is that, completely installed, it weighs only 300 lb.







REAR-ON VIEWS IN THE CAB OF THE U. S. NAVAL AIRSHIP L-1. LEADER OF CAB, 40 FEET TWO HUNDRED-SEVEN. PHOTO BY A. L. LORING FOR SERVICE.

## Course in Aerodynamics and Airplane Design

### Part III.—Experimental Aeronautical Engineering

By Alexander Klemin

Technical Editor, *Aircraft and Aeronautical Engineering*, Consulting Engineer, Aerial Mail Service, Consulting Aeronautical Engineer  
(Copyright, 1910, by Alexander Klemin)

### Section 5. Full Flight Testing

**Physical Data for the Atmosphere.**—Full flight testing may have one of two objects: first, the routine testing of a new airplane for speed at different altitudes, climb, stalling and maneuverability; second, research testing for purposes of aerodynamic investigation. We shall confine ourselves to a consideration of routine performance testing solely. Even routine performance testing involves the possibility of many errors, and requires great care and, above all, standardized methods.

From this also follows the useful equation

$$\frac{D}{W} = \frac{P}{T}$$

The equation  $D = \frac{PW}{T}$  can be expressed in a number of units.

(a) Density in grams per cubic meter.

Density of air at 0 deg. Cent. (or 32 deg. Fahr.) and 760 mm.

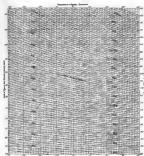


FIG. 1

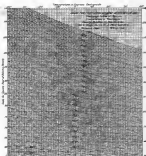


FIG. 2

is clear that few comparisons may be made between units on different planes.

**Formula for Density of Air.**—For a perfect gas,  $PT = RT$  is a well known thermodynamic law, where  $P$  = pressure in suitable units,  $V$  = volume of unit weight,  $R$  = a constant, and  $T$  = absolute temperature.

From this it follows that

$$\frac{1}{V} = \frac{P}{RT}$$

whence  $\frac{1}{V}$  = density in appropriate units,

$$D = \frac{P}{RT} = \text{density formula for all gases.}$$

Or, in more convenient form,

$$D = \frac{PC}{V} \text{ where } C = \frac{1}{R} = \text{some constant.}$$

(or 29.92 in.) equals 2262.5 gm. per cu. in.  
Standard density of air at 32 deg. Cent. (or 89.6 deg. Fahr.) and 760 mm = 1.293 gm. per cu. in.

$$1. \quad D = \frac{P \times 444.80}{T}$$

where  $P$  = pressure in millimeters of mercury at 32 deg. Cent.  
 $T$  = absolute temperature in deg. Cent.

$$2. \quad D = \frac{P \times 1179}{T}$$

where  $P$  = pressure in inches of mercury at 32 deg. Cent.  
 $T$  = absolute temperature in deg. Cent.

= reading on Centigrade scale + 273 deg.

$$3. \quad D = \frac{P \times 2120}{T}$$

where  $P$  = pressure in inches of mercury at 32 deg. Fahr.  
 $T$  = absolute temperature on Fahr. scale

= reading on Fahr. scale + 459.4.

(b) *Density at Standard Pressure.*—Density at sea is 0 day Cent. (or 32 deg. Fahr.) and 760 mm. (or 29.92 in.) = 0.00125 lbs. per cu. ft. Standard density, at sea at 15 deg. Cent. (or 60 deg. Fahr.) and 760 mm. (or 29.92 in.) = 0.00119 lbs. per cu. ft.

At varying pressure and temperature considering D the density at sea at 15,

$$(1) D = \frac{P}{P_0} \times 0.00119$$

where  $P$  = pressure in mm. of mercury at 0 day Cent.  
 $T$  = absolute temperature on C scale

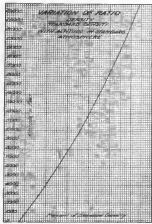


FIG. 2

$$(2) D = \frac{P}{P_0} \times 0.7347$$

where  $P$  = pressure in inches of mercury at 0 day Cent.  
 $T$  = absolute temperature reading on C scale

$$(3) D = \frac{P}{P_0} \times 1.5366$$

where  $P$  = pressure in inches of mercury at 0 day Fahr.  
 $T$  = absolute temperature in Fahr. scale

*Density in percentage of standard density.*—The standard density at 0 day Fahr. (or 32 deg. Cent.) and 760 mm. (or 29.92 in.) has been adopted officially, in British, U.S. and French units, and it would indeed be excellent practice to adopt this standard in American work. All speed indicators are calibrated to this standard density, and density at altitude is referred to the same standard. (See *Standard Units Recommended for U.S.A.*)

These density in mass computations, however, charts have been drawn up, as shown in Figs. 1 and 3. These charts are self-explanatory and will be found very useful. In Fig. 1 the temperature is in Fahrenheit scale and pressure in inches, while in Fig. 3 the temperature is in Centigrade scale and the



FIG. 3

pressure is in inches of mercury. The curves were obtained by using the density formulae of the preceding paragraphs.

*Standard atmosphere.*—In computing the results of climb and speed tests, under varying atmospheric conditions, the

TABLE I

Density in mm. of Mercury at 0 day

Height in Feet	Density in mm. of Mercury
0	760.00
1000	755.00
2000	750.00
3000	745.00
4000	740.00
5000	735.00
6000	730.00
7000	725.00
8000	720.00
9000	715.00
10000	710.00
11000	705.00
12000	700.00
13000	695.00
14000	690.00
15000	685.00
16000	680.00
17000	675.00
18000	670.00
19000	665.00
20000	660.00

British have adopted a standard atmosphere in which a definite ratio of the standard density at 32 deg. Cent. and 760 mm. is taken in comparison to every altitude.

In the accompanying Table I the height in feet and corresponding percentage of standard density are tabulated, and a curve between the two is given in Fig. 3. Performance, both as regards climb and speed, is not de-

pendent on altitude, but solely on density. Hence the adaptation of a standard relation between altitude and density furnishes a true basis of comparison, and still gives a correct reference to altitude, but eliminates variations due to changing weather conditions before a Formula, Temperature and altitude. For a complete understanding of the working of an altimeter or aneroid barometer, it is important to establish the formulae which govern the variation of pressure with temperature and altitude.

If  $P_0$  letters are a column of equal to the atmosphere, and is equivalent under the action of gravity, and the density of gas at 0, then the variation in pressure  $P$  and area is given by the equation

$$dP = -Ddh$$

the negative sign being placed since the pressure is decreased as



FIG. 1

Now since  $D = \frac{P}{AT}$  if  $T$  remains a constant  $D = \frac{P}{A}$  where  $A$  is a constant equal to  $AT = \frac{P}{A}$

The equation  $dP = -Ddh$  can be written  $\frac{A dP}{P} = -dh$

Integrating this equation, we obtain between limits  $P_0$  and  $P$ ,  $h = A \log \frac{P_0}{P}$ , which is known as Halley's formula.

To transform to common logarithms, we divide by the constant 0.4343 and

$$h = \frac{A}{0.4343} \log \frac{P_0}{P} = \frac{A}{0.4343} (\log P_0 - \log P)$$

Halley's formula immediately gives a relation between the pressure at any height where the temperature remains constant. It can be written accurately for other units as British units.

Thus if  $T = 59$  deg. Cent., and pressure  $P_0 = 760$  mm. of mercury is 1013.25 lbs. per sq. in., then

$D = 1.250$  lbs. per cu. in.,  
 $h = 1.250 \log \frac{P_0}{P}$ ,  
 $h = \frac{1.250}{0.4343} \log \frac{P_0}{P}$   
 $h = 2.878 \log \frac{P_0}{P}$   
 $h = 18,400$   
 so that the equation becomes  
 $h = 18,400 (\log P_0 - \log P)$

In English units  $h = 60,367 \log \frac{P_0}{P}$

In Fig. 4 a curve giving this relationship is shown. Correction of Halley's formula for Temperature—Halley's formula takes an equivalence of variations due to change in temperature, in atmosphere density, in variation in gravity at varying altitudes, and in variation in gravity at varying



FIG. 4

density from the center of the earth. Laplace originally developed a formula which took equivalence of all these variations. The most important is that due to temperature.

The first equation in the derivation of Halley's formula is

$$\frac{A dP}{P} = -Ddh$$

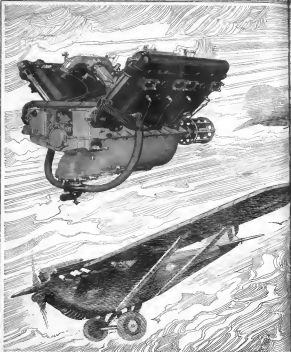
This is true where temperature remains constant. For variation in temperature only,  $\frac{D_0}{D} = \frac{T}{T_0}$ , where  $T$  and  $T_0$  are in absolute temperature units.

Accordingly, if the constant  $A$  in Halley's formula has been defined for a certain temperature  $T_0$ , the integration will become

$$\int \frac{A dP}{P} = \int -D \frac{T}{T_0} dh$$

or

$$\int \frac{A dP}{P} = \int -D \frac{T_0 + t}{T_0} dh$$



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Wright-Martin Aircraft Corporation  
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where  $t_1$  and  $t_2$  are in Cent. or Fahr. units and  $t_3$  is in 253 on Cent. scale and 459.4 on Fahr. scale.

Since temperature does not vary in any direct manner with the altitude, it is impossible to correlate this directly. Between two altitudes where the distance is not too great, it is sufficient to assume to use the mean temperature. In finding altitudes of stream thousands feet where temperature is recorded at intervals, the computed stress are repeated at these altitudes and sufficient accurate results are obtained. In Fig. 9 a correction chart for temperature is given.

Review of altitudes obtained by every curve—If  $f$  is the mean pressure of water in the atmosphere, expressed in lb. per sq. in. at  $P$ , then where  $P$  is calculated from values of  $P$

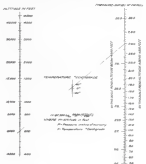


FIG. 7

instead of  $P$  the exposure  $P - 0.227 f$  is employed. This is a very small difference. In the Bureau of Standards altitudes-pressure curve (Fig. 5) difference has been made for humidity. This curve is used for the commercial altitudes of altitudes and barographs, which are always indicated for a temperature of 50 deg. Fahr.

The modified Halley formula for this curve is

$$H = 62500 \log \frac{P_1}{P_2}$$

and the values for the curve are given in table II. Here the dry altitude would purely as a pressure measure, the pressure corresponding to any altitude may be obtained at once (elementary chart for altitudes—Fig. 7 is given in alignment chart for altitudes based on the formula).

$H = 62500 \log \frac{P_1}{P_2}$

at a surface temperature of 30 deg. Cent., or 50 deg. Fahr., and the temperature correction of

$$1273 - t$$

$$(26)$$

This chart would also be absolutely true for high altitudes when the correction temperature is constant throughout. It is approximately true if the mean temperature between the two altitudes is found. It is almost exactly true if differences of altitudes are sought and these differences are small.

To use the chart it is only necessary to lay a straight edge across it diagonally through the correct pressure and temperature points, the reading where the straight edge crosses the altitude scale is the corresponding height. A piece of fine silk

TABLE II

Altitudes, Scale for Altitude

Pressure in lb. per sq. in.

Altitude in Feet	Pressure in lb. per sq. in.	Altitude in Feet	Pressure in lb. per sq. in.
0	14.7	10000	10.0
1000	14.5	20000	7.0
2000	14.3	30000	5.0
3000	14.1	40000	3.5
4000	13.9	50000	2.5
5000	13.7	60000	1.8
6000	13.5	70000	1.3
7000	13.3	80000	1.0
8000	13.1	90000	0.7
9000	12.9	100000	0.5
10000	12.7	110000	0.4
11000	12.5	120000	0.3
12000	12.3	130000	0.2
13000	12.1	140000	0.1
14000	11.9	150000	0.1
15000	11.7	160000	0.0
16000	11.5	170000	0.0
17000	11.3	180000	0.0
18000	11.1	190000	0.0
19000	10.9	200000	0.0
20000	10.7	210000	0.0
21000	10.5	220000	0.0
22000	10.3	230000	0.0
23000	10.1	240000	0.0
24000	9.9	250000	0.0
25000	9.7	260000	0.0
26000	9.5	270000	0.0
27000	9.3	280000	0.0
28000	9.1	290000	0.0
29000	8.9	300000	0.0
30000	8.7	310000	0.0
31000	8.5	320000	0.0
32000	8.3	330000	0.0
33000	8.1	340000	0.0
34000	7.9	350000	0.0
35000	7.7	360000	0.0
36000	7.5	370000	0.0
37000	7.3	380000	0.0
38000	7.1	390000	0.0
39000	6.9	400000	0.0
40000	6.7	410000	0.0
41000	6.5	420000	0.0
42000	6.3	430000	0.0
43000	6.1	440000	0.0
44000	5.9	450000	0.0
45000	5.7	460000	0.0
46000	5.5	470000	0.0
47000	5.3	480000	0.0
48000	5.1	490000	0.0
49000	4.9	500000	0.0

thread lightly stretched between the thumb force a very convenient straight edge. The altitude scale is graduated to read heights from 4000 to 40,000 ft. on the outside scale and from 400 to 4,000 ft. on the inside scale. The pressure scale is graduated both sides in correspondence with the altitude scale. It is only necessary to remember that whatever the pressure be on the inside scale the correct altitude will be found on the inside scale also.

## Aeronautical Patents

Patents Granted in U. S.

- 1,280,840.—To John F. Hall, Brooklyn, N. Y. Flying machine.  
1,280,841.—To Robert F. Adams, Chicago, Ill. Flying machine.  
1,280,842.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,843.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,844.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,845.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,846.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,847.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,848.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,849.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,850.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,851.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
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1,280,860.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.

Patents Granted in U. S.

- 1,280,861.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,862.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,863.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,864.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,865.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,866.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,867.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,868.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,869.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,870.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,871.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
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1,280,879.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.  
1,280,880.—To Charles E. Smith, Pittsburgh, Pa. Flying machine.

## Veneer Body Construction

Test of UXB-1 Model

When a UXB-1 Model—This body, built for a live test in the upper fighter, had layers of solid gray glass, with insulating skin and bulkheads (Fig. 5). The outer glass in the bulkheads were interrupted, of size and length, when the core was at skin in some cases, and at popular outposts and large in others. The skin was wound in the bulkheads with glass and brass wires, it varied in thickness from 3/32 to 5/32 in. the number of horizontal, outside from three to seven, with the same wires in all cases horizontal. The number of horizontal in the bulkheads varied from seven to thirteen, with a total thickness of from 1/2 to 7/8 in.

The weight of the complete body was 260 lb., approximated as follows:

Component	Weight
Insulating	60.0
Outer skin	60.0
Inner skin	10.0
Outer layers and inner skin	10.0
Insulating	10.0
Wire	10.0
Inner skin, glass	10.0
Inner skin, wire	10.0
Inner skin, wire	10.0
Total	260.0



FIG. 5. UXB-1 MODEL IN THE TEST

Fig. 5 is a half section of the body shown in a view of failure under a light loading of the skin on the bottom members, with a front of the rear support. After an application of load, the front plate fitting bolted in the body failed in shearing out the life wire holes. Coming to this load failure of a specimen to say how much greater load this body could have withstood before general failure would have occurred. There was, however, no failure at any of the joints, which were long never proved together, and the thickness of the proved highly satisfactory, giving probably higher total strength than the same or both and popular bodies of the same size which were tested subsequently.

At the time of failure the total load on the body supports was 11,000 lb., of which 4800 lb. were on the front support. If held on the same, given an expected load loading of 20.8 lb. per sq. in.

On the UXB-1 Model—Type No. 3. This, the first of a series of veneer bodies made by the DuPont-Potomac Co. for the UXB-1, is a one-piece fighter, panel with a conventional and typical construction (Fig. 6).

The veneer skin had seven glass plates with the green large bulkheads, throughout, and had layers of outer fabric between all plates. As in the previous type the skin was not the same throughout the body, but varied from two to three plates with a total thickness of from 1/2 to 3/4 in. It was wound in the bulkheads and insulating with wire and glass.

\* Continued from last issue

A detail drawing of the bulkhead at station 5, where the point of attachment for the rear left wing was located, is shown in Fig. 7. Most of the other bulkheads were square, with a minimum width of 36 in. and with thickness ranging from 3/4 to 1 in. at the front portion, and 3/4 to 1 in. at the rear. The four foremost bulkheads extended beyond the body to at least the framework for the upper and lower fins.

There were four horizontal, six forward and square all, the upper being square at station 8, and the lower being square at station 6 and 7 (Fig. 8). The curved surfaces of these square were covered in such a manner that a cross-section through them would show a row of teeth 6 in. deep, thus being due to increase the glued area. All square were wrapped with tape and glass.

This body weighed, as tested, without wing anchorage



FIG. 6. FRONT END VIEW OF THE DUPOINT-POTOMAC UXB-1 MODEL

Weight, 260 lb., approximated as follows:

Component	Weight
Insulating	60.0
Outer skin	60.0
Inner skin	10.0
Outer layers and inner skin	10.0
Insulating	10.0
Wire	10.0
Inner skin, glass	10.0
Inner skin, wire	10.0
Inner skin, wire	10.0
Total	260.0

In the first test the body was supported directly on a test stand by means of blocks at the center of the bottom and guided with HRT. Up to a dynamic loading of 5 psf failure occurred. The test was then discontinued and the body set up supported by regular struts, but the second test turned out badly, owing to failure of one of the supports. It was quite clear, however, to observe that this body could have withstood a dynamic loading of 5.

On the UXB-1 Model—Type No. 4.—This body differed from the one just described except in that the skin was made of seven glass plates with outer sheathing between. Motion and outer from station 2 to 10 (Fig. 9) were three-ply with the green of the face plate instead of horizontally. The latter were 6 in. thick, and the rear 1/2 in. thick. The whole was sand-filled down to a thickness of 1/2 in. The remainder of the skin was of a thickness of 1/2 in. thickness per ply, the whole being sand-filled down to 1/2 in. thickness.

The bulkheads were of plywood varying from three-ply to

in skin to eleven-ply 1 in. thick. It is interesting that the longerons were very easily in line with the side of the bulkheads, so that there was no necessity of strain of the shear stress such as would failure in some of the USC-3s have previously noted.

The longerons were identical with those of the previous type. In all cases the vertical force of the longerons was seen to the skin.

This body exhibited a dynamic loading of 7.5 before final failure occurred and thus proved of very satisfactory strength, as compared with previous examples, which is attributed to the elimination of local weaknesses, the distribution of the grain and the use of fabric between the plies of the skin. There were signs of strain in the sides and wrinkling of the skin long before actual failure occurred, but the latter is much less serious in a body having a layer of fabric between the plies of the skin, the fabric transmitting considerable resistance to buckling and splitting.

**Design Pattern (USXB-1) Type No. 3.**—This body was previously identical with the two just noted, with the exception of the following structural changes:

The bottom and the sides from station 1 to 19 (Fig. 8) were of eleven-ply spruce 1/32 in. thick centrally, with a fabric between the plies. The floor plies on this portion were 1/4 in. thick with longitudinal grain, while the cap was 1/32 in. thick with transverse grain. The skin in the rear portion of the

body was 5/8 in. thick, consisting of outside plies 1/32 in. thick with longitudinal grain and a core of 1/24 in. thickness with transverse grain.

Some of the bulkheads were 5/8 in. and 3/4 in. thick, made of eleven-ply wood, while others were 1 in. in thickness, made of eleven-ply. The bulkhead at station 7 formed the point of attachment for the SR wires, and similar reinforcement strips were fastened to the bulkheads, varying from 2 in. at this point to 5/8 in. in the rear portion.

The upper longerons were of ash down station 1 to 9, and of spruce in this rear section, while the lower longerons were throughout of spruce.

Under a dynamic loading of 6.5 longitudinal cracks commenced to show in the skin near station 7, giving evidence of

high shearing stresses at that point. These cracks occurred on the next increased load, and under a further load of 7 the upper longerons split at station 7 and the skin failed near by due to the vertical stress.

This test showed that the maximum of failure between the plies slightly reduced the strength of this body, for the Devin-Peterson Type 2 body had a higher wire throughout than Type 3 and also had a smaller total weight, yet it developed a higher strength than the third body, which is highly instructive.

#### Recommendations

As a result of the above tests on various type airplane bodies the following principal recommendations may be set down for the use of airplane designers:

(1) The vapor skin should be made with a large proportion of the grain running longitudinally and with the floor plies of hardwood.

(2) The use of real long cross (not merely stringers) is sound.

(3) The stiffening of the center skin with the usual diagonal bulkheads is not as difficult, necessarily stronger for this purpose, by bulkheads, the bottom of the skin has a decided compression value, consequently it is superior to one completely strong lower longerons.

(4) When properly attached, the bottom of the skin has a decided compression value, consequently it is superior to one completely strong lower longerons.

(5) The skin is considerably strengthened by the use of carbon sheathing between the plies.

(6) Care should be exercised to see that the joints or splices



FIG. 8. AIRCRAFT DRAWING OF THE USXB-1 VEHICLE POTENTIAL

the skin do not occur at points of great stress.

(7) The upper longerons should be strengthened at out-lets such as the wingtips.

(8) Bulkheads should be so designed that they will stand up well under local reactions and bending moment applied by the SR wires.

(9) Very careful manufacture should be maintained in order to insure good uniform results.

For the benefit of airplane designers, a general summary drawing of a typical reserve fuselage for the USXB-1, or Devin-Peterson combat airplane, is illustrated in Fig. 8, with the principal dimensions and dimensions of stations. All station numbers as the description of the USXB-1 refer to this drawing.

## Tailoring of Airship Envelopes

By R. H. Upson

Manufacture of airships has developed both abroad and in this country in accord to the established American practice of "tailoring" airship envelopes, which from their various advantages usually thought peculiar to rigid airships without adopting the desired streamlined shape. This article does not deal with the detail of pattern construction, which is a time and material process, nor with the theory of water models and static design in general, but simply sets forth some basic ideas underlying this subject.

As a rule it is necessary to tailor a rigid airship envelope unless all the loading reactions are balanced against each other at each point along the ship. If carefully calculated, this can be done by adjusting the following items in correct proportion:

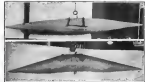


FIG. 1. UPSON AIRSHIP MODEL, POOLING WITH AIR  
FIG. 2. (UPSON) THE NAME, POOLING WITH WATER

size and shape of envelope, length and weight of gas, distance between nose and envelope, angle of suspension, size and position of ballast, weight and location of its grain, weight and position of distributed power plants, general reaction.

But tailoring is not always advisable, as, for instance, when the general design and purpose of the ship brings the various components into line, position which makes it unnecessary to approximate a good envelope form by other methods. This shows, however, a very limited shape at the position of various three main parts, nose, ballast and tail. These requirements are different for almost every different design of airship, and in fact few cases do they work out completely to a distribution of load which in itself will eliminate distortion in the gas bag.

When the loads (excluding moments) are not distributed uniformly along the gas bag, a rigid envelope will hold its shape, but a non-rigid will be distorted or bent under the influence of tension and shear. A rubber tyrod form of distribution is shown in the accompanying illustrations. This is a small water model, made of parallel fabric to show better how it distorts. Fig. 1 shows the model inflated with air, while Fig. 2 shows the same model inflated with water and the photograph turned right side up illustrates the appearance of the gas-filled balloon.

The parallel fabric has practically no resistance to shear, hence the pronounced double S-shape curve which is formed. This effect is slight in large compared to that of the direct tension. It will be noted that the ribs of the inflated balloon curve upward in what would be expected from the force or gravity, also that in spite of distortion the length of the top curve from crest to crest is approximately the same as that of the bottom curve. If the fabric had no stretch, the top and bottom curves would be exactly the same length, but the shape would not look very different. This is approximately the effect of curve assumed by the early Latvian airships in France (which were built of parallel fabric), and is a loose and much less degree in rigid non-rigid bag with a single air

The proper amount of tailoring in flexible envelopes is determined:

(a) By water model tests showing the amount of distortion necessary to be overcome.

(b) By correction based on the form of the final shape of any new design.

judgment based on observation of similar types of ships and a comparison of ballast moments.

The tailoring is done by cutting out "p" shaped vertical strips from either the top or bottom of the envelope body. It is found in experiment that these strips may be as wide as 10 in. without appreciably changing the fabric or steady tensioning effect. Conversely, the strips may be as narrow as 1/2 in. without being noticeable as strips of 2 in. maximum width.

The final new may be set down as follows:

(a) To get a balance which is more equally symmetrical in shape to keep the reactions down to a minimum.

(b) To get the horizontal line parallel to the mean axis.

(c) To produce a balance which is straight and neat in appearance.

(d) To keep the fabric stresses within proper limits. When an envelope is over-stretched it will hold its shape, on the average, indefinitely. The tailoring is based on the actual conditions in regard to make adjustments, say in ballast, fuel in tanks, etc. Variations in the shape are noted to occur due to changes in the above conditions and due to irregularities in the fabric. That these variations are slight, however, is proven by the very uniform appearance of all airships which have been subject to standardized specifications. In the design of new ships it has been found better to err in getting the tail a little too high rather than too low, because there are always some ways of pulling it down, thus letting it up. In all this it should be remembered that the height of the tail and the angle of the tail are two different things, which must often be handled in different ways.

## Flight License Compulsory

The Joint Army and Navy Board on Aeronautics Commission writes to call attention to an occurrence at recent date, the seriousness of which is apparent in every case.

On March 26, 1928, during the parade held in celebration of the home coming of the 28th Division at New York City, a flying boat was sent up to fly down the Hudson River. The aircraft showed the parade at a dangerously low altitude estimated to be from three to five hundred feet, which was so low that in case of error before the pilot would have had no chance except to land in the river or the Hudson. He could not have passed over a group of Central Park trees to the number of trees.

Incidentally, has developed that this loss was piloted by a civilian who was flying without the license required by the Provisional of the President of the United States on February 26, 1928. This gentleman's presence that a license issued by the Joint Army and Navy Board on Aeronautics Commission by or on behalf of any person who recognizes flying in a balloon, airplane, dirigible, or other machine or device over the whole of the United States, the District of Columbia, the Panama Canal Zone, the Hawaiian Islands, and the Panama Canal Zone. Heavy penalties are attached in violation of this regulation.

There is no way of adequately providing for the public safety, where airplanes fly so low over an airfield even over a large assembly of people. In case of accident a pilot would be liable to offend immediately, and human life and property would be endangered in a serious degree. All persons operating aircraft are cautioned against the repetition of an occurrence such as the one which took place in New York City. The Board on Aeronautics Commission is hereby expressing its opinion of any airplane or balloon, they must first obtain a license from the Joint Army and Navy Board on Aeronautics Commission.





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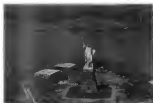
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June 5, 1919



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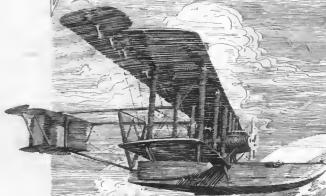
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